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(54) **SYSTEM FOR A SURFACE COOLER WITH  
OGV ORIENTED FIN ANGLES**

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(52) **U.S. Cl.**

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**2260/213** (2013.01); **F05D 2260/22141**  
(2013.01)

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**25/12**; **F01D 5/185**; **F01D 5/186**; **F01D**  
**5/187**

USPC ..... **60/785**, **39**, **83**, **730**

See application file for complete search history.

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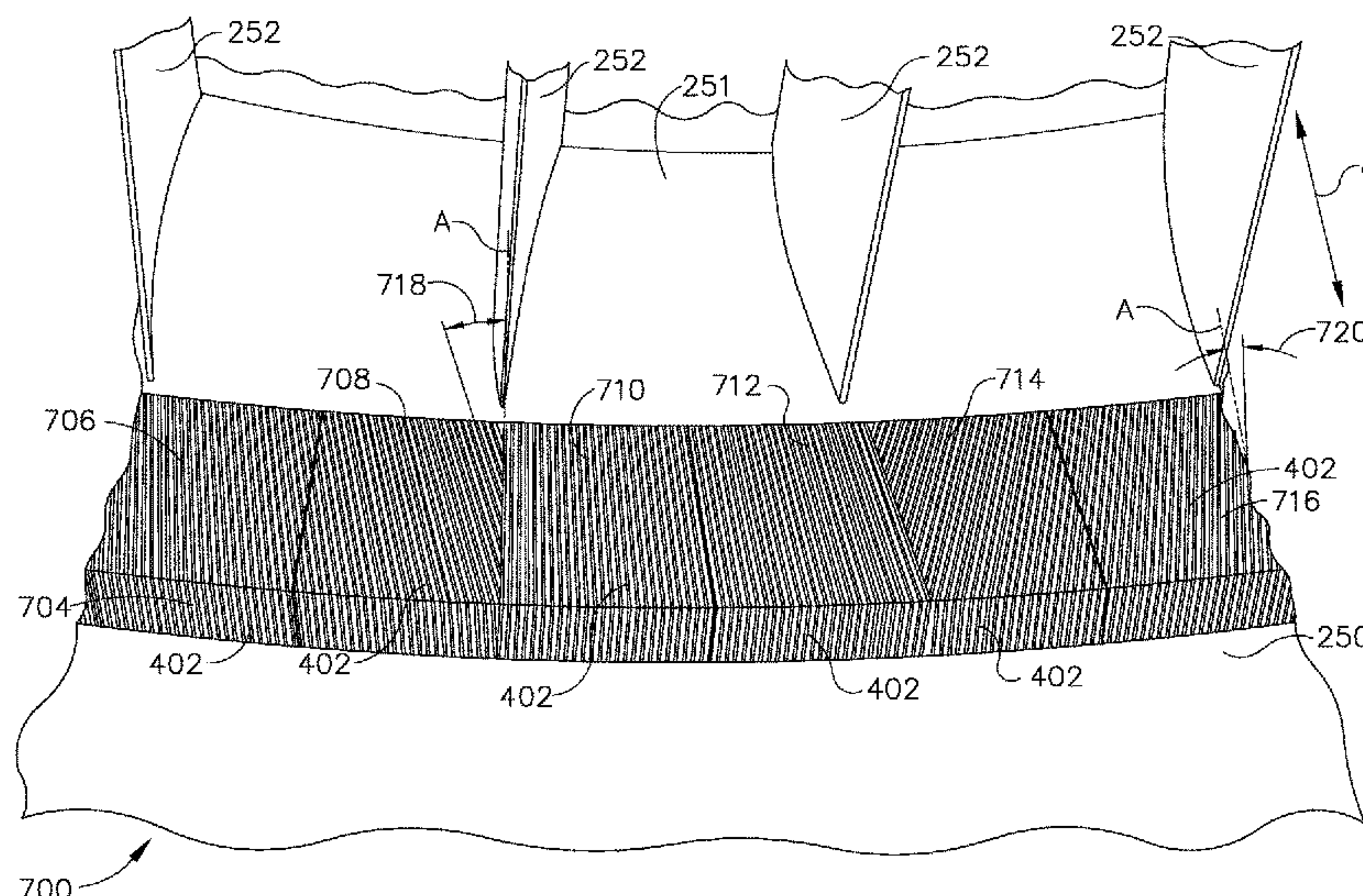
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(57)

**ABSTRACT**

The heat exchanger assembly includes a first conduit, an external surface, and a set of fins. The first conduit includes a first inlet, a first outlet, and a first internal flow path extending between the first inlet and first outlet. The first conduit is configured to channel a flow of fluid to be cooled from the first inlet to the first outlet. The external surface which includes a plurality of regions. Each region of the plurality of regions includes a respective set of fins extending from the external surface. Each set of fins of a respective region of the plurality of regions are oriented in a different direction than sets of fins of other regions of the plurality of regions.

**12 Claims, 7 Drawing Sheets**



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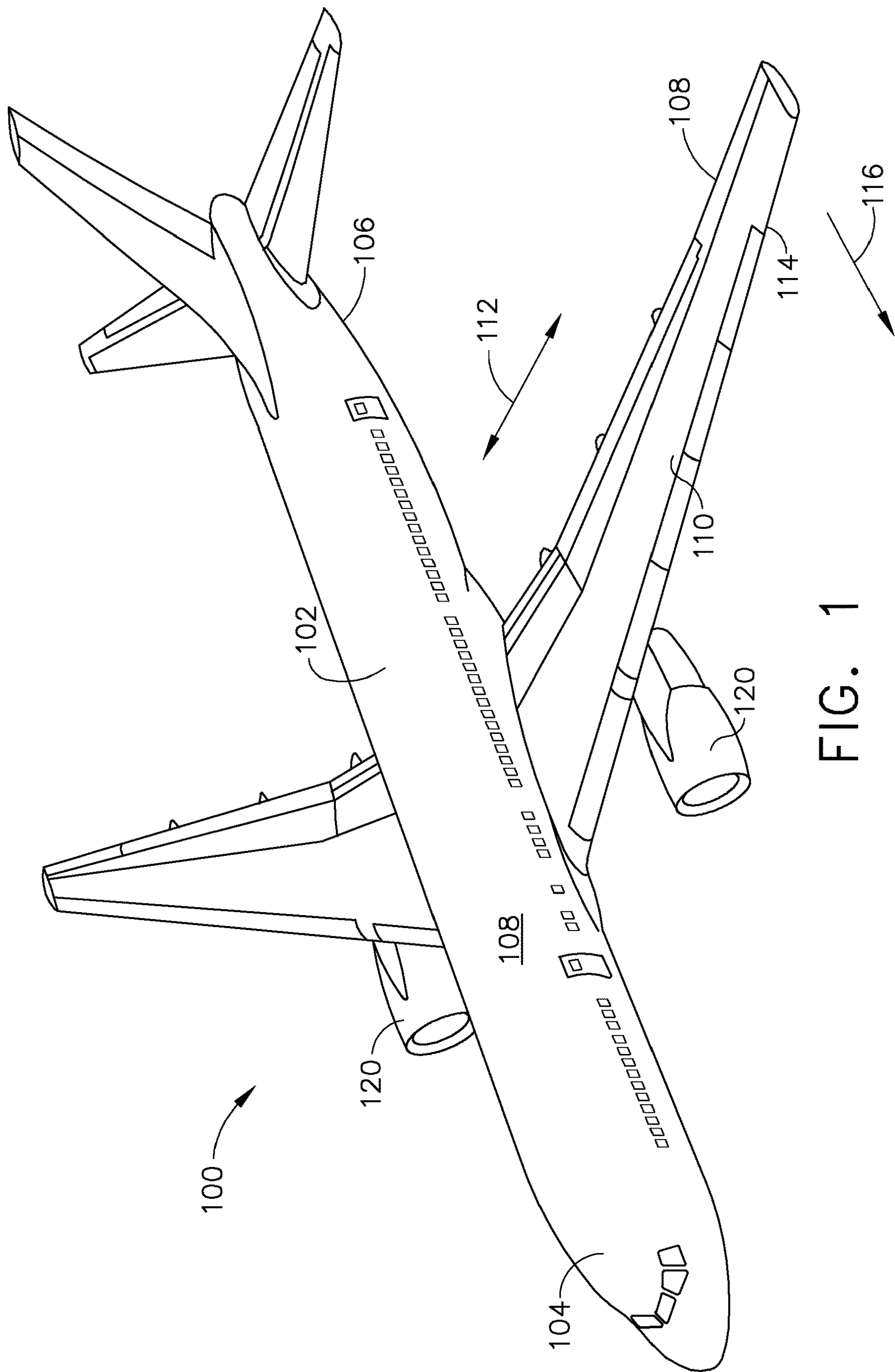


FIG. 1



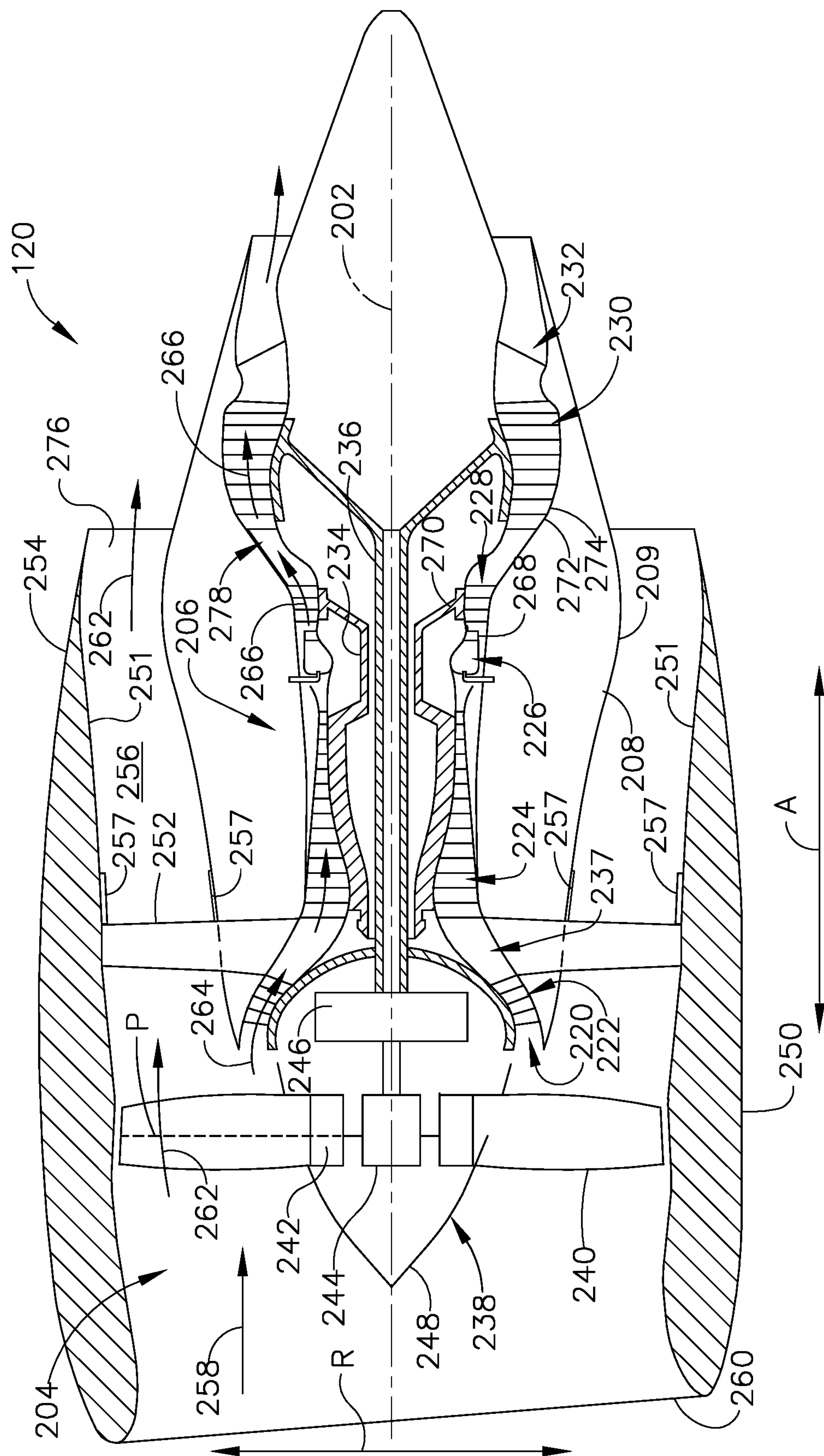
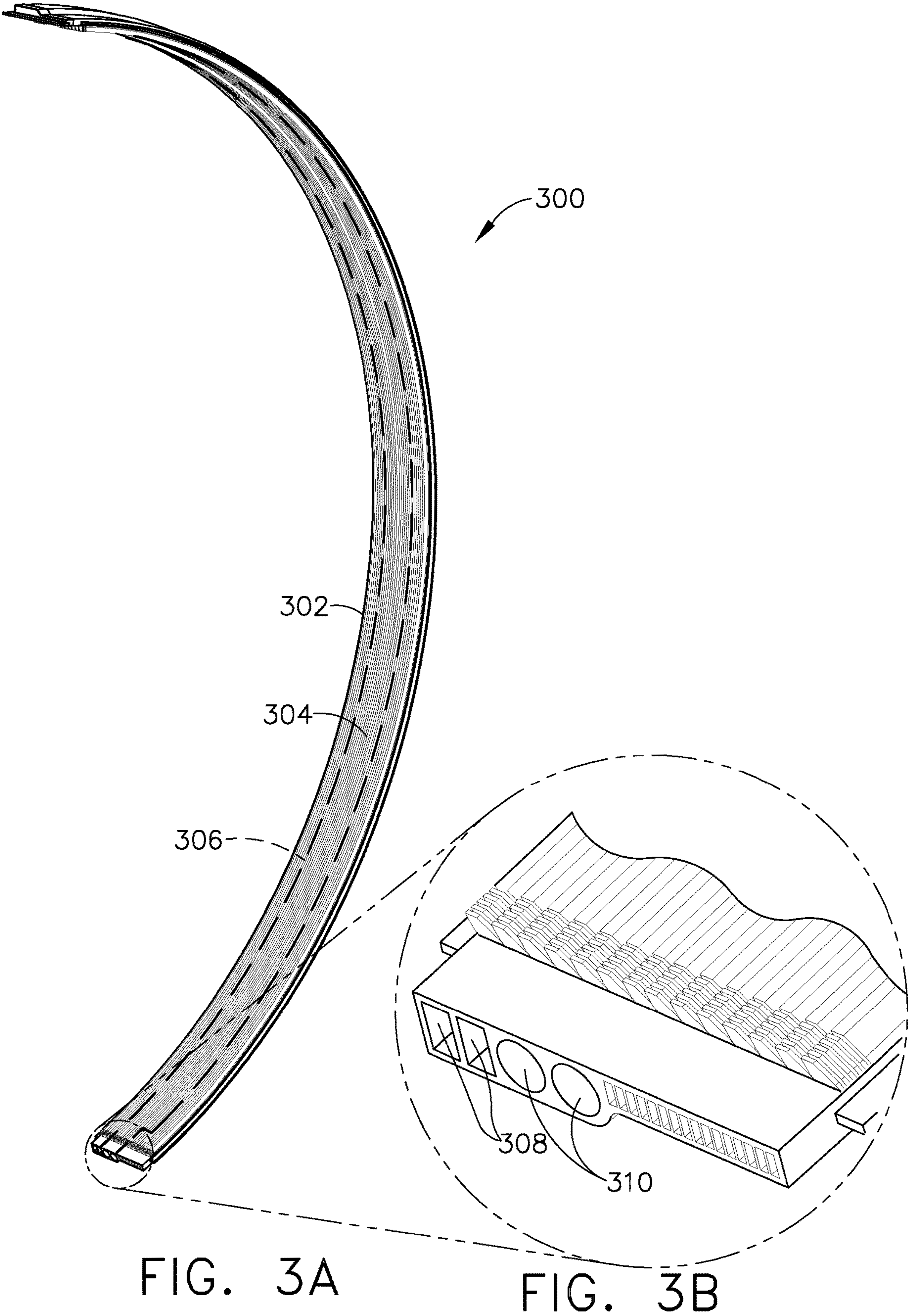


FIG. 2



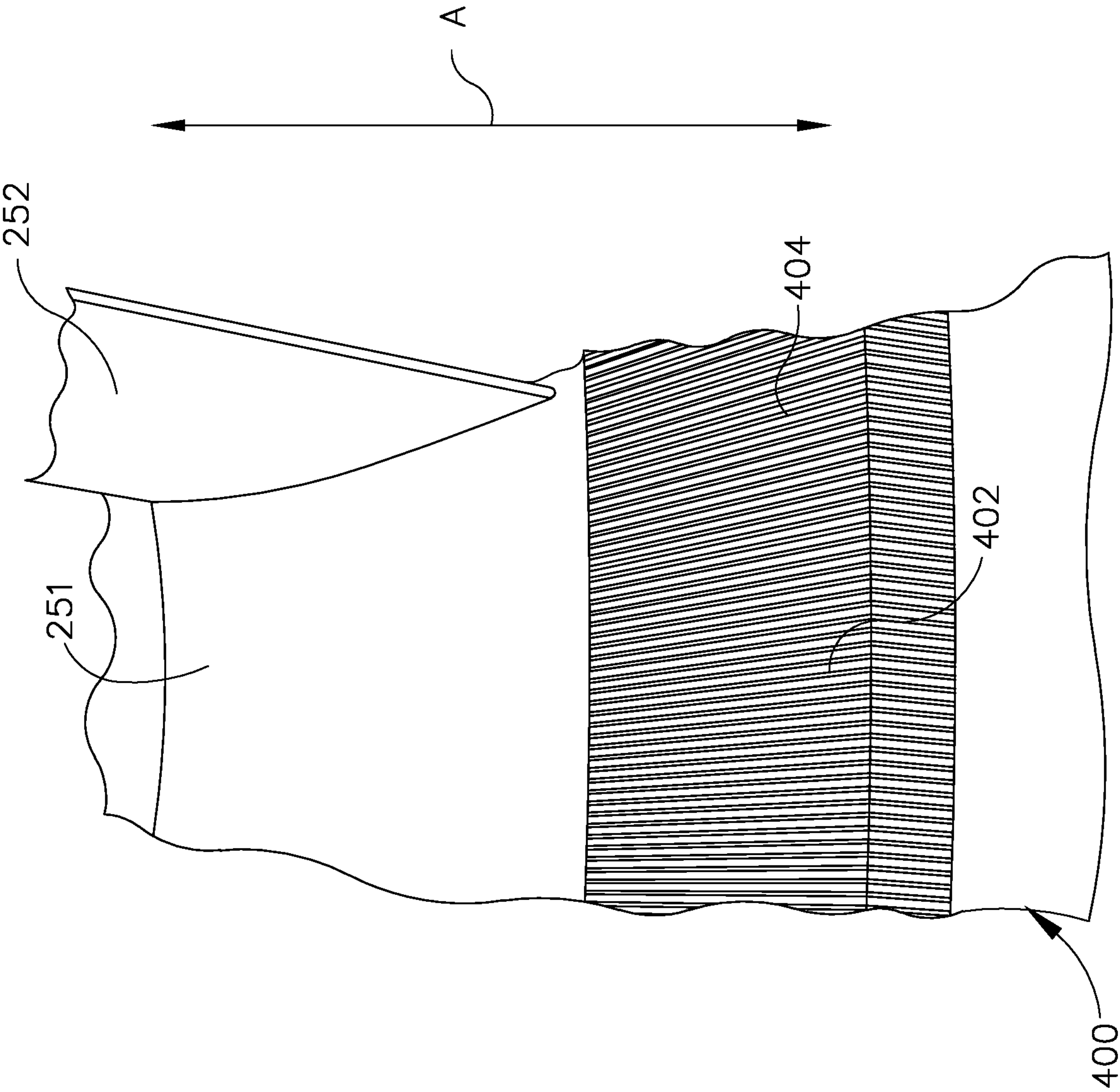


FIG. 4



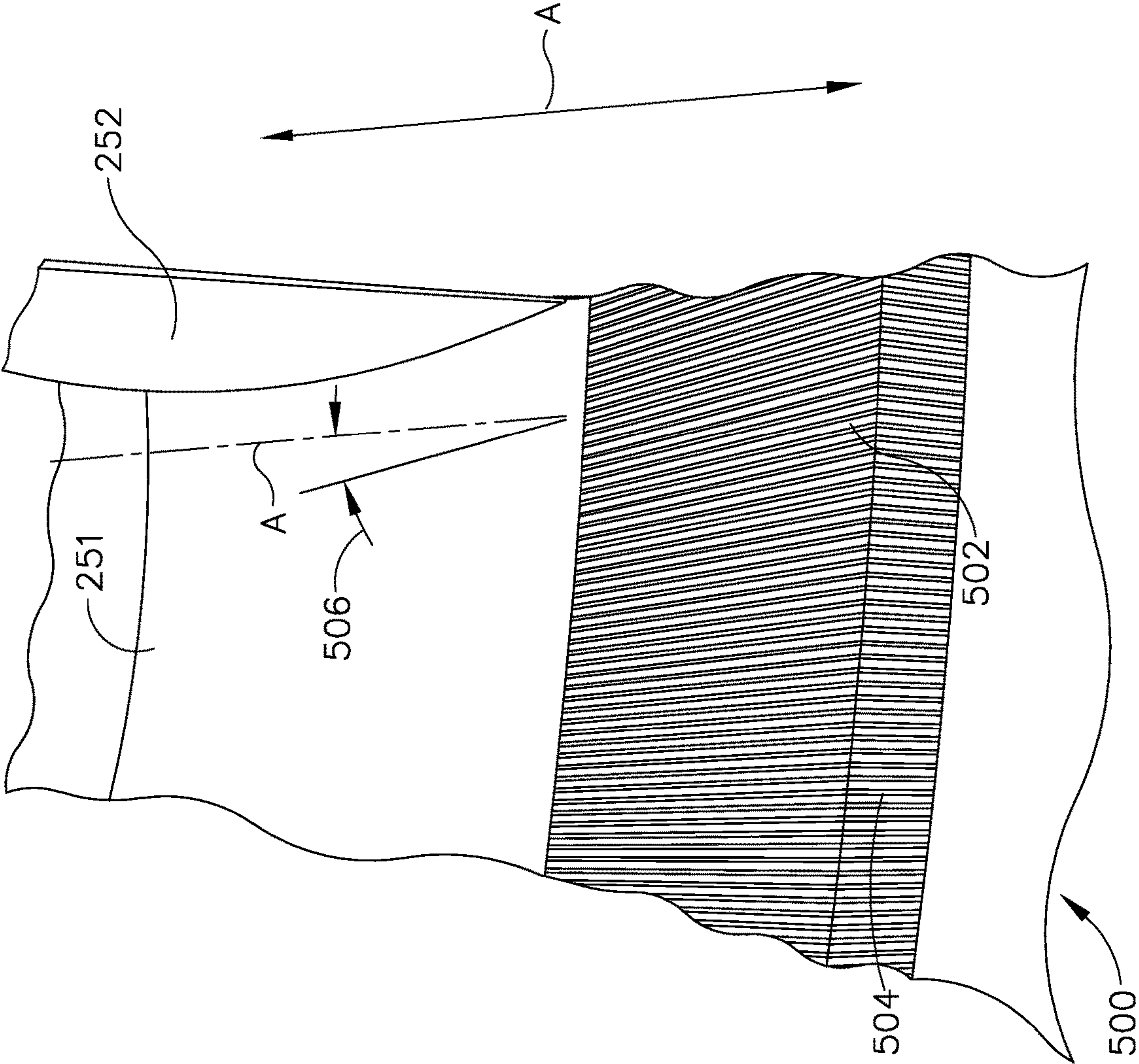


FIG. 5

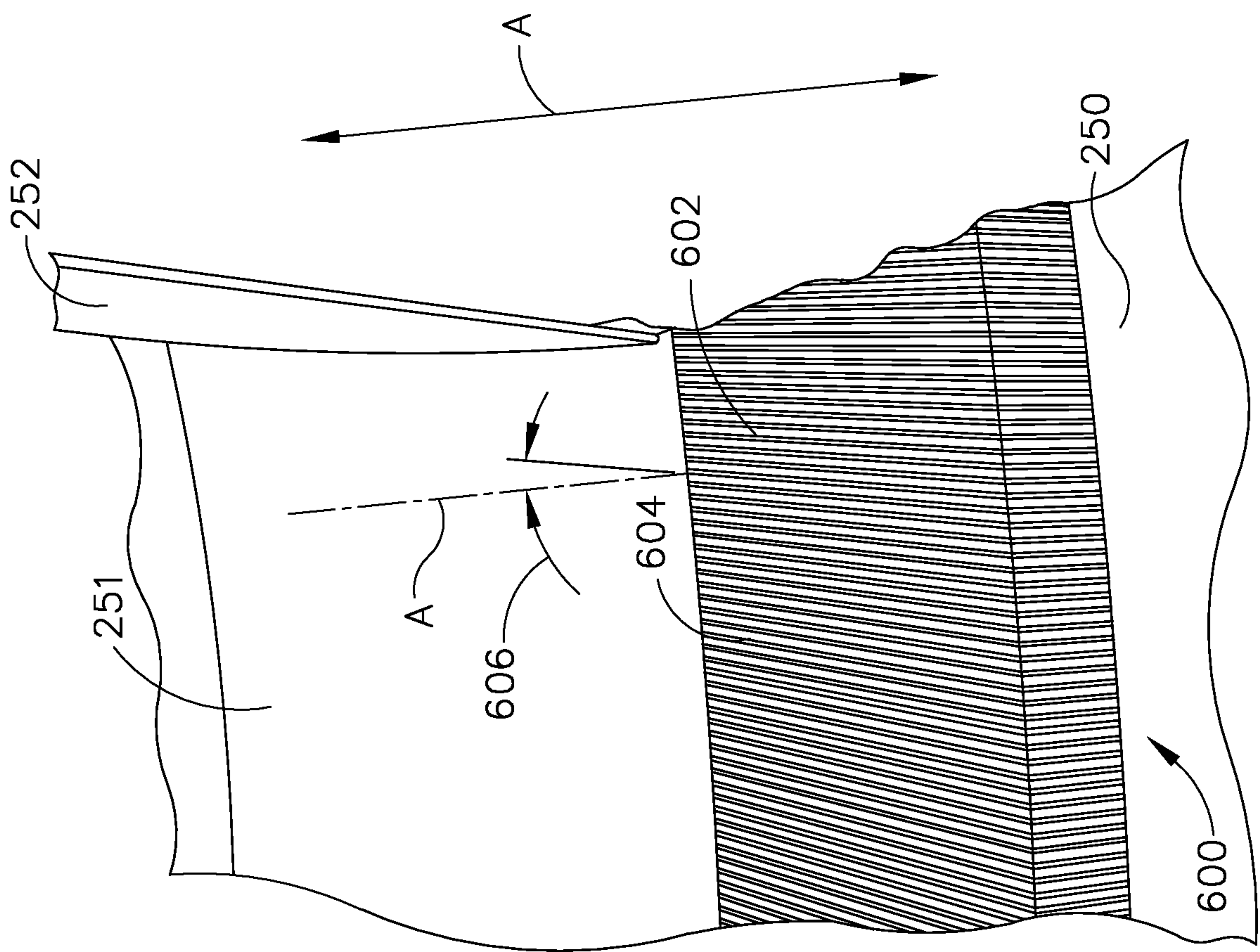


FIG. 6



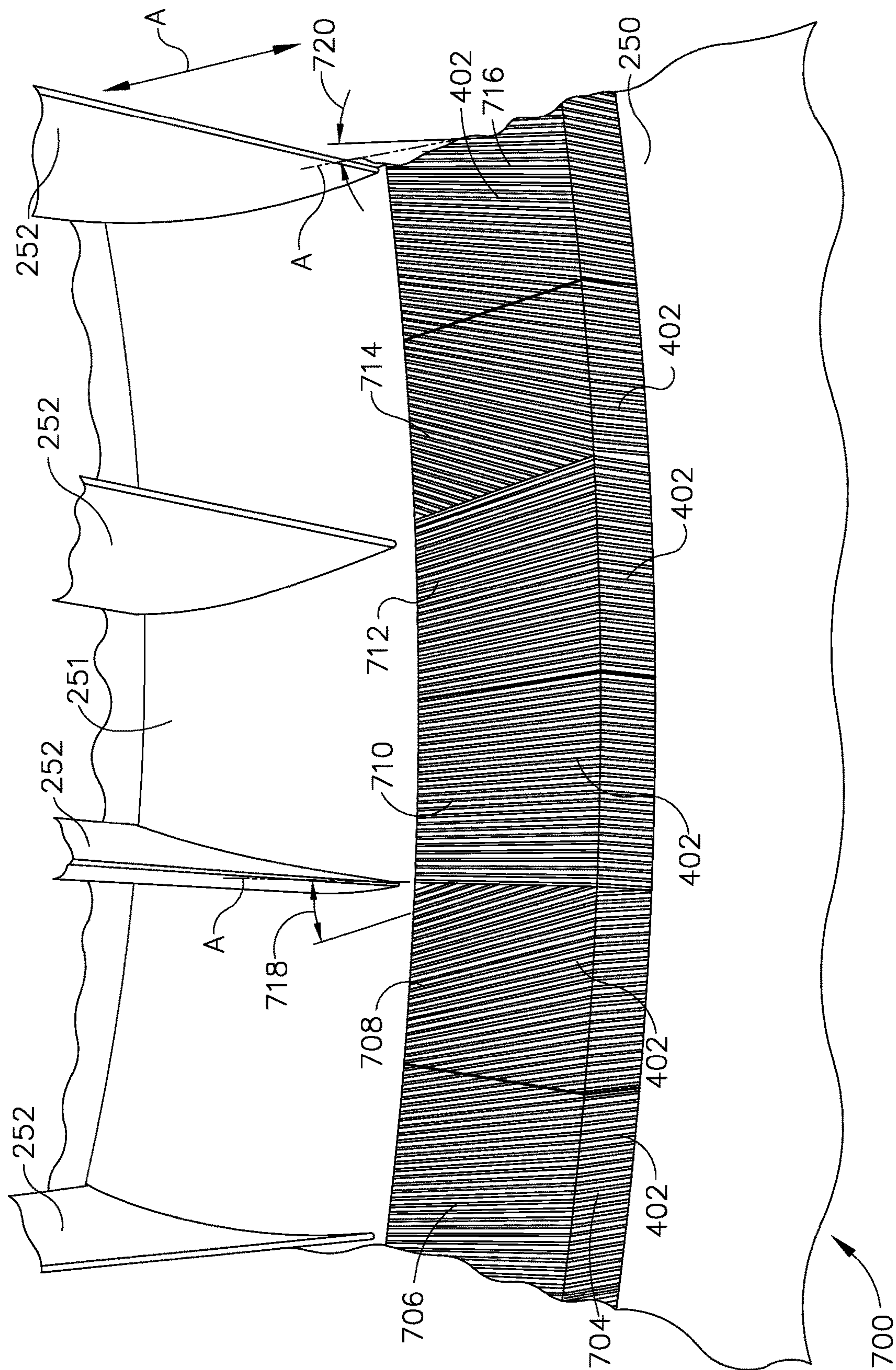


FIG. 7



## SYSTEM FOR A SURFACE COOLER WITH OGV ORIENTED FIN ANGLES

### BACKGROUND

The field of the disclosure relates generally to gas turbine engines and, more particularly, to a method and system for surface coolers in a gas turbine engine.

At least some known gas turbine engines include one or more oil cooling systems that are configured to cool and lubricate components of gas turbine engines. Some gas turbine engines include an air-oil surface cooler heat exchanger attached to the inner radial surface of the nacelle or the outer radial surface of the gas turbine engine that use fan air to cool the oil flowing through the air-oil heat exchanger. Air-oil surface coolers include fins protruding into the bypass airflow passageway that exchange heat with the relatively cold fan air. The fins cause friction losses to the air flowing through the bypass airflow passageway which reduces the fuel efficiency of the engine.

### BRIEF DESCRIPTION

In one aspect, a heat exchanger assembly is provided. The heat exchanger assembly includes a first conduit, an external surface, and a set of fins. The first conduit includes a first inlet, a first outlet, and a first internal flow path extending between the first inlet and first outlet. The first conduit is configured to channel a flow of fluid to be cooled from the first inlet to the first outlet. The external surface includes a plurality of regions. Each region of the plurality of regions includes a respective set of fins extending from the external surface. Each set of fins of a respective region of the plurality of regions are oriented in a different direction than sets of fins of other regions of the plurality of regions.

In another aspect, a gas turbine engine is provided. The gas turbine engine includes a core engine, a bypass duct, a plurality of airfoil members, and a heat exchanger assembly. The bypass duct at least partially surrounds the core engine. The plurality of airfoil members extend between the bypass duct and the core engine. The core engine includes the heat exchanger assembly which includes a first conduit, an external surface, and a set of fins. The first conduit includes a first inlet, a first outlet, and a first internal flow path extending between the first inlet and first outlet. The first conduit is configured to channel a flow of fluid to be cooled from the first inlet to the first outlet. The external surface includes a plurality of regions. Each region of the plurality of regions includes a respective set of fins extending from the external surface. Each set of fins of a respective region of the plurality of regions are oriented in a different direction than sets of fins of other regions of the plurality of regions.

In yet another aspect, an aircraft is provided. The aircraft includes a fuselage, a wing, and a gas turbine engine assembly. The fuselage includes a nose, a tail, and a hollow, elongate body extending therebetween. The wing extends laterally away from the fuselage. The gas turbine engine assembly is configured to drive a bladed rotatable member and is coupled to at least one of the wing or the fuselage. The gas turbine engine assembly includes a core engine, a bypass duct, a plurality of airfoil members, and a heat exchanger assembly. The bypass duct at least partially surrounds the core engine. The plurality of airfoil members extend between the bypass duct and the core engine. The core engine includes the heat exchanger assembly which includes a first conduit, an external surface, and a set of fins. The first conduit includes a first inlet, a first outlet, and a first internal

flow path extending between the first inlet and first outlet. The first conduit is configured to channel a flow of fluid to be cooled from the first inlet to the first outlet. The external surface includes a plurality of regions. Each region of the plurality of regions includes a respective set of fins extending from the external surface. Each set of fins of a respective region of the plurality of regions are oriented in a different direction than sets of fins of other regions of the plurality of regions.

### BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present disclosure will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

FIGS. 1-7 show example embodiments of the method and apparatus described herein.

FIG. 1 is a perspective view of an aircraft.

FIG. 2 is a schematic cross-sectional view of a gas turbine engine in accordance with an exemplary embodiment of the present disclosure that may be used with the aircraft shown in FIG. 1.

FIG. 3A is a schematic diagram of a surface cooler.

FIG. 3B is a schematic diagram of a surface cooler inlet and outlet.

FIG. 4 is a perspective view of a surface cooler disposed on an inner radial surface of nacelle.

FIG. 5 is a perspective view of another surface cooler disposed on inner radial surface of nacelle.

FIG. 6 is a perspective view of another surface cooler disposed on inner radial surface of nacelle.

FIG. 7 is a perspective view of another surface cooler disposed on inner radial surface of nacelle.

Although specific features of various embodiments may be shown in some drawings and not in others, this is for convenience only. Any feature of any drawing may be referenced and/or claimed in combination with any feature of any other drawing.

Unless otherwise indicated, the drawings provided herein are meant to illustrate features of embodiments of the disclosure. These features are believed to be applicable in a wide variety of systems comprising one or more embodiments of the disclosure. As such, the drawings are not meant to include all conventional features known by those of ordinary skill in the art to be required for the practice of the embodiments disclosed herein.

### DETAILED DESCRIPTION

In the following specification and the claims, reference will be made to a number of terms, which shall be defined to have the following meanings.

The singular forms “a”, “an”, and “the” include plural references unless the context clearly dictates otherwise.

“Optional” or “optionally” means that the subsequently described event or circumstance may or may not occur, and that the description includes instances where the event occurs and instances where it does not.

Approximating language, as used herein throughout the specification and claims, may be applied to modify any quantitative representation that could permissibly vary without resulting in a change in the basic function to which it is related. Accordingly, a value modified by a term or terms, such as “about”, “approximately”, and “substantially”, are not to be limited to the precise value specified. In at least



some instances, the approximating language may correspond to the precision of an instrument for measuring the value. Here and throughout the specification and claims, range limitations may be combined and/or interchanged; such ranges are identified and include all the sub-ranges contained therein unless context or language indicates otherwise.

The following detailed description illustrates embodiments of the disclosure by way of example and not by way of limitation. It is contemplated that the disclosure has general application to a system for cooling oil in an aircraft engine.

Embodiments of the heat exchanger assembly described herein cool oil in a gas turbine engine assembly. A nacelle at least partially surrounding the gas turbine engine forms a fan bypass duct therebetween. The heat exchanger assembly includes an air-oil heat exchanger located on an inner radial surface of the nacelle or on an outer radial surface of the gas turbine engine exposed to air flowing in the fan bypass duct. The air-oil heat exchanger includes a first flow path for channeling oil through the heat exchanger internal passages and an external surface for directing air proximate to fins on the external surface. The fins disposed on the external surface of the heat exchanger protrude into the fan bypass duct. The heat exchanger cools the oil by exchanging heat in the oil flowing through the first flow path with fan air in the fan bypass duct. Additionally, outlet guide vanes extending between the nacelle and the gas turbine engine direct the flow of air through the nacelle. The oil flows through the first flow path and the air flows proximate the fins on the external surface. The fins on the external surface of the heat exchanger are aligned in approximately the same direction as the outlet guide vanes to facilitate channeling air flow through the fan bypass duct efficiently to minimize fan air pressure losses.

The heat exchanger assemblies described herein offer advantages over known methods of cooling oil in a gas turbine engine. More specifically, some known heat exchangers orient the fins on the surface of the heat exchanger in one direction regardless of the direction the outlet guide vanes are directing air flow. The fins on the external surface of the heat exchangers described herein direct air flow in the same direction as the outlet guide vanes reducing pressure loss and drag thereby increasing the fuel efficiency of the gas turbine engine.

FIG. 1 is a perspective view of an aircraft 100. In the example embodiment, aircraft 100 includes a fuselage 102 that includes a nose 104, a tail 106, and a hollow, elongate body 108 extending therebetween. Aircraft 100 also includes a wing 110 extending away from fuselage 102 in a lateral direction 112. Wing 110 includes a forward leading edge 114 in a direction 116 of motion of aircraft 100 during normal flight and an aft trailing edge 118 on an opposing edge of wing 110. Aircraft 100 further includes at least one engine 120 configured to drive a bladed rotatable member or fan to generate thrust. Engine 120 is coupled to at least one of wing 110 and fuselage 102, for example, in a pusher configuration (not shown) proximate tail 106.

FIG. 2 is a schematic cross-sectional view of gas turbine engine 120 in accordance with an exemplary embodiment of the present disclosure. In the example embodiment, gas turbine engine 120 is embodied in a high bypass turbofan jet engine. As shown in FIG. 2, turbofan engine 120 defines an axial direction A (extending parallel to a longitudinal axis 202 provided for reference) and a radial direction R. In

general, turbofan 120 includes a fan assembly 204 and a core turbine engine 206 disposed downstream from fan assembly 204.

In the example embodiment, core turbine engine 206 includes an approximately tubular outer casing 208 that defines an annular inlet 220. Outer casing 208 encases, in serial flow relationship, a compressor section including a booster or low pressure (LP) compressor 222 and a high pressure (HP) compressor 224; a combustion section 226; a turbine section including a high pressure (HP) turbine 228 and a low pressure (LP) turbine 230; and a jet exhaust nozzle section 232. Out casing 208 also includes an outer radial surface 209. A high pressure (HP) shaft or spool 234 drivingly connects HP turbine 228 to HP compressor 224. A low pressure (LP) shaft or spool 236 drivingly connects LP turbine 230 to LP compressor 222. The compressor section, combustion section 226, turbine section, and nozzle section 232 together define a core air flowpath 237.

In the example embodiment, fan assembly 204 includes a variable pitch fan 238 having a plurality of fan blades 240 coupled to a disk 242 in a spaced apart relationship. Although fan assembly 204 is described as including a variable pitch fan 238, fan assembly 204 could include a conventional fixed pitch fan. Fan blades 240 extend radially outwardly from disk 242. Each fan blade 240 is rotatable relative to disk 242 about a pitch axis P by virtue of fan blades 240 being operatively coupled to a suitable pitch change mechanism (PCM) 244 configured to vary the pitch of fan blades 240. In other embodiments, PCM 244 is configured to collectively vary the pitch of fan blades 240 in unison. Fan blades 240, disk 242, PCM 244, and LP compressor 222 are together rotatable about longitudinal axis 202 by LP shaft 236 across a power gear box 246.

Disk 242 is covered by rotatable front hub 248 aerodynamically contoured to promote an airflow through the plurality of fan blades 240. Additionally, fan assembly 204 includes an annular fan casing or outer nacelle 250 that circumferentially surrounds fan 238 and/or at least a portion of core turbine engine 206. Nacelle 250 includes an inner radial surface 251. In the example embodiment, nacelle 250 is configured to be supported relative to core turbine engine 206 by a plurality of circumferentially-spaced outlet guide vanes 252. Moreover, a downstream section 254 of nacelle 250 may extend over an outer portion of core turbine engine 206 so as to define a bypass airflow passage 256 therebetween. A plurality of surface coolers 257 is disposed on inner radial surface 251 of nacelle 250 in bypass airflow passage 256 aft of outlet guide vanes 252. In an alternative embodiment, surface coolers 257 are disposed on outer casing 208 aft of outlet guide vanes 252. In the exemplary embodiment, surface coolers 257 are disposed on inner or outer radial surface 251 of nacelle 250 in bypass airflow passage 256 aft of outlet guide vanes 252 less than 2 inches from the trailing edge of outlet guide vanes 252. However, surface coolers 257 may be disposed on inner or outer radial surfaces 251 of nacelle 250 in bypass airflow passage 256 at any location that enables surface coolers 257 to operate as described herein. Surface coolers 257 are configured to channel a flow of fluid through internal conduits to cool the fluid with airflow in the bypass airflow passage 256. In exemplary embodiment, the fluid cooled by surface coolers 257 is oil. However, in alternative embodiments, surface coolers 257 may be configured to cool fuel or any other suitable fluid.

During operation of turbofan engine 120, a volume of air 258 enters turbofan 120 through an associated inlet 260 of nacelle 250 and/or fan assembly 204. As volume of air 258 passes across fan blades 240, a first portion 262 of volume



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of air **258** is directed or routed into bypass airflow passage **256** and a second portion **264** of volume of air **258** is directed or routed into core air flowpath **237**, or more specifically into LP compressor **222**. First portion of air **262** flows proximate to a surface of surface coolers **257** and cools oil within surface coolers **257**. A ratio between first portion **262** and second portion **264** is commonly referred to as a bypass ratio. The pressure of second portion **264** is then increased as it is routed through HP compressor **224** and into combustion section **226**, where it is mixed with fuel and burned to provide combustion gases **266**.

Combustion gases **266** are routed through HP turbine **228** where a portion of thermal and/or kinetic energy from combustion gases **266** is extracted via sequential stages of HP turbine stator vanes **268** that are coupled to outer casing **208** and HP turbine rotor blades **270** that are coupled to HP shaft or spool **234**, thus causing HP shaft or spool **234** to rotate, which then drives a rotation of HP compressor **224**. Combustion gases **266** are then routed through LP turbine **230** where a second portion of thermal and kinetic energy is extracted from combustion gases **266** via sequential stages of LP turbine stator vanes **272** that are coupled to outer casing **208** and LP turbine rotor blades **274** that are coupled to LP shaft or spool **236**, which drives a rotation of LP shaft or spool **236**, LP compressor **222**, and rotation of fan **238** across power gear box **246**.

Combustion gases **266** are subsequently routed through jet exhaust nozzle section **232** of core turbine engine **206** to provide propulsive thrust. Simultaneously, the pressure of first portion **262** is substantially increased as first portion **262** is routed through bypass airflow passage **256** before it is exhausted from a fan nozzle exhaust section **276** of turbofan **120**, also providing propulsive thrust. HP turbine **228**, LP turbine **230**, and jet exhaust nozzle section **232** at least partially define a hot gas path **278** for routing combustion gases **266** through core turbine engine **206**.

Exemplary turbofan engine **120** depicted in FIG. 2 is by way of example only, and in other embodiments, turbofan engine **120** may have any other suitable configuration. It should also be appreciated, that in still other embodiments, aspects of the present disclosure may be incorporated into any other suitable gas turbine engine. For example, in other embodiments, aspects of the present disclosure may be incorporated into, e.g., a turboprop engine. In other embodiments, turbofan engine **120** may be an unducted fan engine with surface coolers **257** disposed on outer casing **208**.

FIG. 3A is a schematic diagram of a surface cooler **300**. FIG. 3B is a schematic diagram of a surface cooler **300** inlet and outlet. Surface cooler **300** includes a surface **302** disposed on inner radial surface **251** (shown in FIG. 2) of nacelle **250** (shown in FIG. 2). In an alternative embodiment, surface cooler **300** includes a surface **302** disposed on outer radial surface **209** (shown in FIG. 2) of outer casing **208** (shown in FIG. 2). Surface cooler **300** also includes a plurality of fin members **304** disposed on surface **302** and extending into bypass airflow passage **256** (shown in FIG. 2). Surface cooler **300** includes a surface cooler inlet **308**, a surface cooler outlet **310**, and one or more internal flow paths **306** extending therebetween.

During operation, first portion of air **262** (shown in FIG. 2) in bypass airflow passage **256** (shown in FIG. 2) is configured to flow proximate to surface **302** to exchange heat with fin members **304**. Surface cooler inlet **308** is configured to receive a flow of oil to be cooled and channel oil to internal flow paths **306**. Oil in internal flow paths **306** is configured to exchange heat with first portion of air **262** (shown in FIG. 2) through fin members **304**. Internal flow

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paths **306** are configured to channel oil to surface cooler outlet **310** which is configured to return oil to core turbine engine **206** (shown in FIG. 2).

FIG. 4 is a perspective view of a surface cooler **400** disposed on inner radial surface **251** of nacelle **250**. FIG. 5 is a perspective view of a surface cooler **500** disposed on inner radial surface **251** of nacelle **250**. FIG. 6 is a perspective view of a surface cooler **600** disposed on inner radial surface **251** of nacelle **250**. Surface coolers **400**, **500**, and **600** are each positioned axially aft of outlet guide vanes **252**. Surface coolers **400**, **500**, and **600** each include a plurality of fins **402**, **502**, and **602** respectively disposed on an external surface **404**, **504**, and **604** of surface coolers **400**, **500**, and **600**. Each fin of the plurality of fins **502** and **602** are oriented in an angle of orientation **506** and **606** with respect to axial direction A. Plurality of fins **402** align with axial direction A and direct first portion of air **262** (shown in FIG. 2) in axial direction A. Plurality of fins **502** are configured at a zero (0) to negative thirty (−30) degree angle of orientation **506** with respect to axial direction A. Plurality of fins **602** are configured at a zero (0) to positive thirty (+30) degree angle of orientation **606** with respect to axial direction A.

Changing the angle of orientation **406**, **506**, and **606** of plurality of fins **402**, **502**, and **602** permits plurality of fins **402**, **502**, and **602** to direct portion of air **262** in directions other than the axial direction A. Outlet guide vanes **252** directs first portion of air **262** in directions other than axial direction A to straighten the flow of first portion of air **262**. Plurality of fins **402**, **502**, and **602** may be oriented to direct first portion of air **262** in the same direction as the outlet guide vanes **252** direct first portion of air **262**. Directing air flow in the same direction as the outlet guide vanes **252** reduces pressure loss and drag and increases the fuel efficiency of gas turbine engine **120**.

FIG. 7 is a perspective view of a surface cooler **700** disposed on inner radial surface **251** of nacelle **250**. Surface cooler **700** is positioned axially aft of outlet guide vanes **252**. Surface cooler **700** includes a plurality of fins **702** disposed on an external surface **704** of surface cooler **700**. External surface **704** of surface cooler **700** is divided into a plurality of regions **706**, **708**, **710**, **712**, **714**, and **716**. Each fin of the plurality of fins **702** within regions **706**, **708**, **714**, and **716** are oriented in an angle of orientation **718** and **720** with respect to axial direction A. In the exemplary embodiment, plurality of fins **702** within regions **710** and **712** align with axial direction A and direct first portion of air **262** (shown in FIG. 2) in axial direction A. Plurality of fins **702** within region **706** and **708** are configured at a zero (0) to negative thirty (−30) degree angle of orientation **718** with respect to axial direction A. Additionally, plurality of fins **702** within regions **714**, and **716** are configured at a zero (0) to positive thirty (+30) degree angle of orientation **720** with respect to axial direction A.

Changing the angles of orientation **718** and **720** of plurality of fins **702** permits the plurality of fins **702** to direct portion of air **262** in directions other than the axial direction A. In the exemplary embodiment, outlet guide vanes **252** directs first portion of air **262** in directions other than axial direction A to straighten the flow of first portion of air **262**. Plurality of fins **702** within regions **706**, **708**, **714**, and **716** may be oriented to direct first portion of air **262** in the same direction as the outlet guide vanes **252** direct first portion of air **262**. Directing air flow in the same direction as the outlet guide vanes **252** reduces pressure loss and drag and increases the fuel efficiency of gas turbine engine **120**. Each region of the plurality of regions **706**, **708**, **710**, **712**, **714**,



and 716 may direct air in the same direction as other regions or may direct air in a different direction.

The above-described heat exchange assemblies provide an efficient method for cooling oil in a gas turbine engine. Specifically, the above-described heat exchange assembly directs air flow in the fan bypass duct in the same direction outlet guide vanes direct air flow in the fan bypass duct. Directing air flow in the same direction as the outlet guide vanes reduces pressure loss and drag. As such, reducing pressure loss within the fan bypass duct increases the fuel efficiency of the gas turbine engine.

Exemplary embodiments of the heat exchanger assembly are described above in detail. The heat exchanger assembly, and methods of operating such systems and devices are not limited to the specific embodiments described herein, but rather, components of systems and/or steps of the methods may be utilized independently and separately from other components and/or steps described herein. For example, the methods may also be used in combination with other systems requiring oil cooling, and are not limited to practice with only the systems and methods as described herein. Rather, the exemplary embodiment can be implemented and utilized in connection with many other machinery applications that are currently configured to receive and accept heat exchanger assemblies.

Example methods and apparatus for cooling oil with air are described above in detail. The apparatus illustrated is not limited to the specific embodiments described herein, but rather, components of each may be utilized independently and separately from other components described herein. Each system component can also be used in combination with other system components.

This written description uses examples to describe the disclosure, including the best mode, and also to enable any person skilled in the art to practice the disclosure, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the disclosure is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A heat exchanger assembly comprising:

a first conduit comprising a first inlet, a first outlet, and a first internal flow path extending therebetween, the first conduit configured to channel a flow of fluid to be cooled from the first inlet to the first outlet; and

an external surface comprising a plurality of circumferentially adjacent regions, the plurality of circumferentially adjacent regions comprising a first region circumferentially adjacent to a second region, the first region comprising a first plurality of rows of fins extending away from the external surface, respective ones of the first plurality of rows of fins being circumferentially adjacent to one another and oriented in a first direction, the second region comprising a second plurality of rows of fins extending away from the external surface, respective ones of the second plurality of rows of fins being circumferentially adjacent to one another and oriented in a second direction, the second direction differing from the first direction,

wherein the heat exchanger assembly is configured for installation in a bypass airflow passage of a turbofan engine, the heat exchanger assembly configured to be

positioned axially aft of a plurality of outlet guide vanes circumferentially spaced in the bypass airflow passage, and wherein the external surface is configured to receive a flow of a coolant comprising bypass air in heat transfer communication with the external surface, and

wherein the first direction is selected based at least in part on an orientation of a first outlet guide vane from among the plurality of outlet guide vanes such that the first plurality of rows of fins are configured to direct a first portion of air in the bypass airflow passage to flow in a direction coinciding with the first outlet guide vane, and the second direction is selected based at least in part on an orientation of a second outlet guide vane from among the plurality of outlet guide vanes such that the second plurality of rows of fins are configured to direct a second portion of air in the bypass airflow passage to flow in a direction coinciding with the second outlet guide vane.

2. The heat exchanger assembly of claim 1, wherein the first direction and the second direction differ from one another by an angle, the angle being from 0 to 60 degrees.

3. The heat exchanger assembly of claim 1, wherein the first direction includes values in a range from 0 to 30 degrees relative to an axial direction of the heat exchanger assembly, and/or the second direction includes values in a range from -30 to 0 degrees relative to the axial direction of the heat exchanger assembly.

4. The heat exchanger assembly of claim 3, wherein the first plurality of rows of fins are oriented in the axial direction and the second plurality of rows of fins are oriented in a direction that differs from the axial direction.

5. A gas turbine engine comprising:

a core engine comprising a heat exchanger assembly comprising:

a first conduit comprising a first inlet, a first outlet, and a first internal flow path extending therebetween, the first conduit configured to channel a flow of fluid to be cooled from the first inlet to the first outlet;

an external surface comprising a plurality of circumferentially adjacent regions, the plurality of circumferentially adjacent regions comprising a first region circumferentially adjacent to a second region, the first region comprising a first plurality of rows of fins extending away from the external surface, respective ones of the first plurality of rows of fins being circumferentially adjacent to one another and oriented in a first direction, the second region comprising a second plurality of rows of fins extending away from the external surface, respective ones of the second plurality of rows of fins being circumferentially adjacent to one another and oriented in a second direction, the second direction differing from the first direction;

a bypass duct at least partially surrounding the core engine; and

a plurality of airfoil members extending between the bypass duct and the core engine,

wherein the heat exchanger assembly is configured for installation in the bypass duct, the heat exchanger assembly configured to be positioned axially aft of a plurality of outlet guide vanes circumferentially spaced in the bypass duct, and wherein the external surface is configured to receive a flow of a coolant comprising bypass air in heat transfer communication with the external surface, and

wherein the first direction is selected based at least in part on an orientation of a first outlet guide vane from



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among the plurality of outlet guide vanes such that the first plurality of rows of fins are configured to direct a first portion of air in the bypass duct to flow in a direction coinciding with the first outlet guide vane, and the second direction is selected based at least in part on an orientation of a second outlet guide vane from among the plurality of outlet guide vanes such that the second plurality of rows of fins are configured to direct a second portion of air in the bypass duct to flow in a direction coinciding with the second outlet guide vane.

6. The gas turbine engine of claim 5, wherein the first direction and the second direction differ from one another by an angle, the angle being from 0 to 60 degrees.

7. The gas turbine engine of claim 5, wherein the first direction includes values in a range from 0 to 30 degrees relative to an axial direction of the gas turbine engine, and/or the second direction includes values in a range from -30 to 0 degrees relative to the axial direction of the gas turbine engine.

8. The gas turbine engine of claim 7, wherein the first plurality of rows of fins are oriented in the axial direction and the second plurality of rows of fins are oriented in a direction that differs from the axial direction.

9. A gas turbine engine assembly configured to drive a bladed rotatable member, the gas turbine engine assembly comprising:

a core engine comprising a high pressure compressor, a combustor, and a high pressure turbine in a serial flow arrangement, the core engine further comprising a heat exchanger assembly comprising:

a first conduit comprising a first inlet, a first outlet, and a first internal flow path extending therebetween, the first conduit configured to channel a flow of fluid to be cooled from the first inlet to the first outlet;

an external surface comprising a plurality of regions, the plurality of regions comprising a first region and a second region, the first region comprising a first plurality of rows of fins extending away from the external surface, respective ones of the first plurality of rows of fins being circumferentially adjacent to one another and oriented in a first direction, the second region comprising a second plurality of rows of fins extending away from the external surface,

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respective ones of the second plurality of rows of fins being circumferentially adjacent to one another and oriented in a second direction, the second direction differing from the first direction;

a bypass duct at least partially surrounding the core engine; and

a plurality of airfoil members extending between the bypass duct and the core engine,

wherein the heat exchanger assembly is configured for installation in the bypass duct, the heat exchanger assembly configured to be positioned axially aft of a plurality of outlet guide vanes circumferentially spaced in the bypass duct, and wherein the external surface is configured to receive a flow of a coolant in heat transfer communication with the external surface, and

wherein the first direction is selected based at least in part on an orientation of a first outlet guide vane from among the plurality of outlet guide vanes such that the first plurality of rows of fins are configured to direct a first portion of air in the bypass duct to flow in a direction coinciding with the first outlet guide vane, and the second direction is selected based at least in part on an orientation of a second outlet guide vane from among the plurality of outlet guide vanes such that the second plurality of rows of fins are configured to direct a second portion of air in the bypass duct to flow in a direction coinciding with the second outlet guide vane.

10. The gas turbine engine assembly of claim 9, wherein the first direction and the second direction differ from one another by an angle, the angle being from 0 to 60 degrees.

11. The gas turbine engine assembly of claim 9, wherein the first direction includes values in a range from 0 to 30 degrees relative to an axial direction of the core engine, and/or the second direction includes values in a range from -30 to 0 degrees relative to the axial direction of the core engine.

12. The gas turbine engine assembly of claim 11, wherein the first plurality of rows of fins are oriented in the axial direction and the second plurality of rows of fins are oriented in a direction that differs from the axial direction.

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